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"Characterization of SWIR Infrared Detector Arrays"

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Submitted by

Donald N.B. Hall Principal Investigator and Director

UNIVERSITY OF HAWAII INSTITUTE FOR ASTRONOMY 2680 Woodlawn Drive Honolulu, Hawaii 96822

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Institute for Astronomy, University of Hawaii, 2680 Woodlawn Drive, Honolulu, HI 96822

Grant NAGW-755 Characterization of SWIR Infrared Detector Arrays

Final Report covering the period from January 1989 through November 1994

Principal Investigator, Dr. Donald N. B. Hall

This is the final report on NASA grant NAGW-755, "Characterization of SWIR Infrared Detector Arrays" covering the period from January 1989 through November 1994

Under grant NAGW-755, the Institute for Astronomy has tested and characterized infrared detector arrays of the NICMOS 3 type, produced by the Rockwell International Science Center in Thousand Oaks, California. These NICMOS 3 devices were trional Science Center in Thousand Oaks, California. These NICMOS (Near Inprototypes of the infrared detector arrays used for the NASA NICMOS (Near Infrared Camera and Multi Object Spectrograph) project of an infrared instrument for the Hubble Space Telescope (HST). The NICMOS project is run by the University of Arizona, and the independent testing of the NICMOS devices by the Institute for Astronomy was intended to provide a second source of test results and additional exacterize in the astronomical characterization of such devices to the NICMOS project. Test and characterization results were reported to and discussed with the NICMOS Test and characterization results were reported to and discussed with the NICMOS Test and characterization of the NICMOS and his technical team on a regular basis.

The NICMOS 3 devices are HgCdTe infrared detector arrays with a cut-off wavelength of $2.5\mu m$. hybridized to a CMOS direct readout multiplexer. The first set of prototypes of these devices was fabricated by the Rockwell International Science Center in 1989, and one of these first devices was delivered to the Institute for Astronomy in January of 1990. Within days of delivery, we put this detector array into operation as an imaging system at the 0.6 m telescope on Mauna Kea, for initial testing, and then at the 2.2 m. These first tests clearly demonstrated that the NICMOS 3 array was far superior to any other detector array previously used in astronomy.

Over the course of the next two years, the NICMOS 3 detector array was used in a large number of different astronomical applications of increasingly demanding nature, to explore the limitations in its performance.

The infrared camera with the NICMOS 3 detector array was used at different tele-

copes, the UH 0.6 m, the UH 2.2 m, and the CFHT 3.6 m, and at different foci ranging from f/8 to f/35. In addition to direct imaging, the infrared camera was also used as the light detector in several high resolution spectrographs, a particularly demanding use of the infrared detector array.

Our test and characterization results can be summarized as follows:

- Our NICMOS 3 device has a read-noise of 53 electrons in double-correlated sampling.
- By using multiple-sampling, that read-noise can be reduced to 26 electrons.
- Electroluminescence from the output amplifiers of the detector array sets the limit to achieving even lower noise values.
- The electroluminescence can be minimized by proper clocking of the detector array multiplexer.
- The dark current is below 1 electron per second.

- \bullet The quantum efficiency at 2.2 μm is 45% and is slightly lower at shorter wavelengths.
- Variations of the quantum efficiency across the array can be corrected for to better than 1% accuracy for photometry of stars.
- Large numbers of individual exposures can be added to detect faint objects. We did not find systematic artifacts from the detectors that would set a limit to this procedure for reaching faint objects.
- The NICMOS 3 detector arrays can be used under low background conditions similar to those expected aboard HST.
- We did not find any difficulties, such as excessive interference fringes, when using the NICMOS 3 array with narrow spectral filters.
- The NICMOS 3 devices show excess dark current of previously exposed pixels. After discussing this issue extensively with the NICMOS project and Rockwell. the NICMOS project developed a clocking scheme to mitigate this problem.

To further test NICMOS 3 prototypes for low resolution spectroscopy, a test system called KSPEC (K-band Spectrograph) was built. This instrument records the full spectrum in all atmospheric transmission windows from 1 - 2.5 μm simultaneously and allows to simulate the optical operating conditions of the detectors in the spectroscopic modes of the NICMOS instrument. With KSPEC, we continued our studies of the residual excess dark current effect and further explored the limitation to low noise performance of NICMOS 3 detector arrays. We found the NICMOS 3 arrays to be fully suited for low-background spectroscopic applications. Since there is a sensitivity gap between individual pixels, proper sampling of the spectrum is critical to the performance of the spectrograph.

Our Technical results are summarized in the follwing publications:

Hodapp, K.-W., Hora, J. L., Irwin, E., & Young, T. 1994, P.A.S.P. 106, 87 "KSPEC - A Near-Infrared Cross-Dispersed Spectrograph"

Hodapp, K.-W., Rayner, J., & Irwin, E. 1992, P.A.S.P. 104, 441 "The University of Hawaii NICMOS-3 Near-Infrared Camera"